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(71) Applicant (*for all designated States except US*): TELSTRA CORPORATION LIMITED [AU/AU]; 242 Exhibition Street, Melbourne, VIC 3000 (AU).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): MARTIN, Andrew, Charles [AU/AU]; 16 Eothen Lane, Kilsyth, VIC 3137 (AU). SYME, Cameron, Mark [AU/AU]; 5 Thomas Street, Myrtleford, VIC 3737 (AU).

(74) Agents: WEBBER, David, Brian et al.; Davies Collison Cave, 1 Little Collins Street, Melbourne, VIC 3000 (AU).

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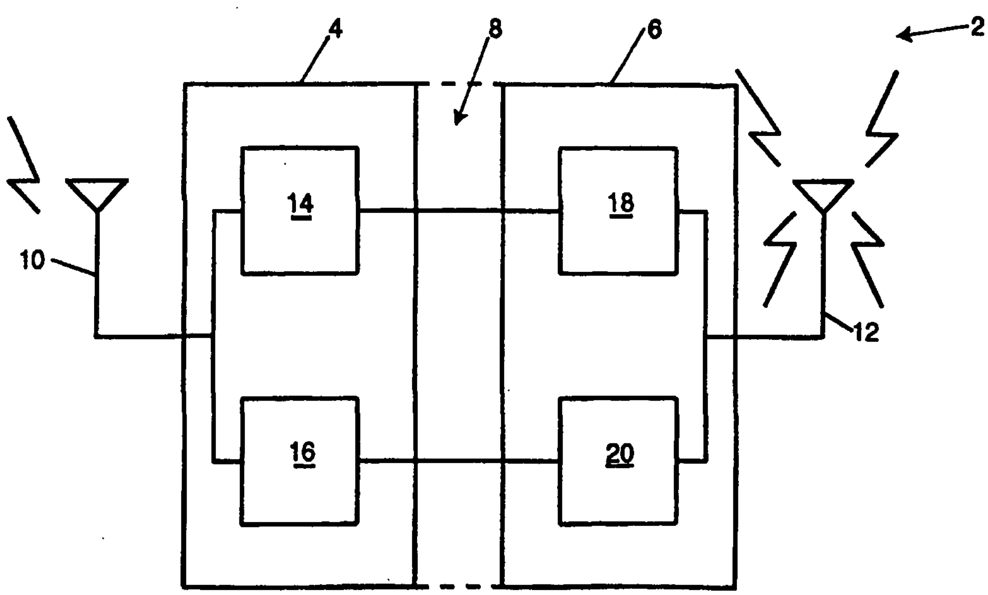
(54) Title: A TRANSMISSION SYSTEM FOR A MOBILE COMMUNICATIONS SIGNAL



(57) Abstract

A transmission system, including a first modem at a first location including a first demodulator for receiving and demodulating RF mobile communications signals into digital signals and a first modulator for modulating digital signals into RF mobile communications signals, and a second modem at a second location including a second demodulator for receiving and demodulating RF mobile communications signals into digital signals and a second modulator for modulating digital signals into RF mobile communications signals, wherein the output of the first demodulator is connected to the second modulator, and the output of the second demodulator is connected to the first modulator, by digital signal transmission media.

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A TRANSMISSION SYSTEM FOR A MOBILE COMMUNICATIONS SIGNAL

The present invention relates to a transmission system and a distribution system for a mobile communications signal, and in particular to a radio frequency (RF) modem.

Base stations of cellular mobile telecommunications systems include transceivers which provide an air interface for the transmission and reception of RF mobile communications signals. The transceivers of the base stations are intended to communicate with mobile stations, or handsets, which move within the range of the cell provided by the base station. As with all RF communications systems, communication with the mobile stations can be compromised by physical obstacles, such as buildings and geographic features, which affect transmission of the RF signals. Accordingly to improve or extend coverage, the RF signals may be intercepted by an antenna and then distributed by a coax cable, or other linear analogue transmission media, to a site where a number of mobile stations may be located. RF repeaters may also be used to receive the RF signal, filter the signal and amplify it for retransmission at a higher signal level, again using analogue filtering and amplification techniques. These transmission and repeating techniques can be used to transport the mobile signal beyond the cell range of the base station to another location where it can be distributed directly to stations or retransmitted to provide another coverage area for the base station.

The above transmission and RF repeating techniques, however, all operate on the modulated RF signal produced by the air interface of the base stations, thereby requiring linear analogue transmission media, and it is desired to be able to utilise simpler, more efficient and more economical transmission media, or at least provide a useful alternative.

In accordance with the present invention there is provided a transmission system for a mobile communications signal, including:

a demodulator at a first location for receiving and demodulating a first RF mobile communications signal into a digital signal; and

a modulator at a second location for modulating said digital signal into a second RF mobile communications signal and transmitting said second signal.

Advantageously, said transmission system may include digital signal transmission media for transmitting said digital signal. The digital signal transmission media may include a microwave link, an optical fibre link, or a telecommunications line for transmitting digital data.

The present invention also provides a transmission system, including:

a first modem at a first location including a first demodulator for receiving and demodulating RF mobile communications signals into digital signals and a first modulator for modulating digital signals into RF mobile communications signals; and

a second modem at a second location including a second demodulator for receiving and demodulating RF mobile communications signals into digital signals and a second modulator for modulating digital signals into RF mobile communications signals,

wherein the output of the first demodulator is connected to the second modulator, and the output of the second demodulator is connected to the first modulator, by digital signal transmission media.

Advantageously, the interfaces may be connected respectively to RF antennas, or alternatively one of the interfaces may be connected to the transceiver of a base station.

The present invention also provides a mobile communications signal modem, including:

a demodulator for receiving and demodulating RF mobile communications signals into serial digital data signals for transmission on a digital communications link; and

a modulator for modulating serial digital data signals received on a digital communications link into RF mobile communications signals.

A preferred embodiment of the present invention is hereinafter described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is a block diagram of a preferred embodiment of a transmission system;

Figure 2 is a block diagram of air interface modems of the transmission system;

Figure 3 is a block diagram of a remote location retransmission system using the modems; and

Figure 4 is a block diagram of a multi-drop/simulcast system using the modems.

A transmission or repeater system 2, as shown in Figure 1, includes two GSM RF modems 4 and 6 which are connected by a serial 270 kbit/s duplex data link 8. The modems 4 and 6 are each able to modulate and demodulate GSM 900/1800 megahertz RF mobile communications signals transmitted and received on antennas 10 and 12 respectively connected to the modems 4 and 6.

The first modem 4 includes a first RF receiver demodulator and regenerator 14 which is connected to the antenna 10 to demodulate the downlink RF signal transmitted by a GSM base station. The downlink signal is a 935-960/1805-1880 megahertz, Gaussian minimum shift keying (GMSK) modulated, RF signal. The receiver 14 demodulates this into a standard RS 422 data signal, or other data line protocol signal, having a rate of 270.833 kbit/s. No equalisation or error correction is applied by the receiver 14 to the communications signal, and non-coherent FM demodulation is employed for simplicity and cost reduction. The data stream produced by the receiver is carried by the link 8 to a second RF transmitter modulator 18 of the second modem 6. The link 8 may be provided by a variety of digital transmission media, as discussed below. The second transmitter modulator 18 receives the data stream from the link 8, conditions the data stream and modulates the data on the stream to produce a GMSK modulated signal in the 935-960/1805-1880 megahertz band. The RF signal is amplified, filtered and fed to the antenna 12 for retransmission.

For the return path for uplink communications to the base station, the second modem 6 has a second RF receiver demodulator regenerator 20, and the first modem 4 has a first RF transmitter modulator 16, which are the same as the first receiver 14 and second modulator 18, respectively, except the former operate at an RF frequency of 890-915/1710-1785 megahertz for the uplink band. The modulators 16 and 18 produce an RF GSM signal which

is in essence the same as the one received by the receiver 14 or 20 of the other modem. Yet the signals are delayed by the propagation delay of the system 2 and may have a different amplitude for the retransmitted signal of the second modulator 18, and will normally have a different amplitude for the first modulator 16 on the uplink path. The amplitude of the retransmitted signal on the uplink path is independent of the power of a mobile handset or station and any path loss between the handset and the second receiver 20. The first modem 4 may be directly connected to the transceiver of a base station. Both of the modems 4 and 6 provide a GSM air interface and a serial data interface.

The receiver 14, 20 of the modems 4 and 6, as shown in Figure 2, is essentially a superheterodyne receiver 22 which includes a data slicer to generate the serial data signals. The receiver 22 first filters and amplifies the incoming RF signal, and then mixes this signal with a local oscillator signal generated by a frequency synthesiser 24. The frequency is selected depending on whether it is operating in the downlink or uplink mode. This produces an intermediate frequency (IF) signal which is filtered by a surface acoustic wave (SAW) filter and then passed to a second mixer, where it is mixed by a crystal generated local oscillator signal of the receiver 22 to produce a second IF signal. The second IF signal is filtered, amplified and limited, and then passed to a quadrature demodulator. The signal output of the quadrature demodulator is an analogue baseband signal representing the original Gaussian filtered data contained in the RF signal. The voltage level of the analogue signal is level compared by the data slicer to generate high and low signals providing the digital data stream of 270.833 kbit/s in NRZ TTL format. To enhance the transmission distance of the NRZ TTL data, drivers/converters 26 are used to convert the data to a balanced transmission format which conforms to the Electrical Industrial Association (EIA) Standard EIA-422-A. The drivers 26 are capable of being set in a power down mode, which enables multiple drivers to be connected on the same line 28 of the data link 8 and operated at different times without affecting each other.

A modulator 16, 18 of the modems 4 and 6 includes a convertor 30, baseband logic 32, a Gaussian filter 34, a quadrature modulator 36 and a clock recovery circuit 38. The convertor 30 receives the RS 422 data signals on the data link 8 and passes them to the

baseband logic circuit 32 in NRZ TTL format. The clock recovery circuit 38 includes a phase locked loop (PLL) circuit which compares the phase of the NRZ format data with that of a local crystal oscillator. If the two signals have a phase error between them, then the error is used to cause a small shift in the frequency of the crystal oscillator until the phases match. The oscillator is used to provide a continuous clock signal which is in-phase with the incoming data and can be used to clock the data at a precise rate so it can be split into two serial data streams by the baseband logic 32.

The baseband logic circuit 32 uses the recovered clock signal from the clock recovery circuit 38 and the incoming data from the converter 30 to generate serial in-phase (I) and quadrature (Q) data streams of 135 kbit/s for the quadrature modulator 36. The logic circuit 32 conditions the two output streams so the correct rotation of the phase vector out of the quadrature modulator 36 occurs with the appropriate baseband data input. For an incoming high signal, the logic circuit 32 produces data on the I and Q lines to generate a positive 90° phase shift on the output of the quadrature modulator 36, whereas for a low signal, the logic circuit 32 produces data on the I and Q lines to generate a negative 90° phase shift.

The I and Q data streams output by the logic circuit 32 are filtered by the Gaussian filter 34 before being fed to the modulator 36. This is required to limit the bandwidth of the RF spectrum after modulation. The filtering requirements for GSM are specified as being a Gaussian filter with a bandwidth to bit ratio of 0.3, ultimately resulting in 0.3 Gaussian minimum shift keying (GMSK). The bandwidth of the filter 34 is set at 81.25 kilohertz. The filter 34 uses switch capacitive filters to generate a fourth order Gaussian low pass filter response.

The frequency synthesiser 24 is used to generate an RF signal for up converting the modulated signal back to a channel in the GSM downlink or uplink band, and for providing an RF signal for the first mixers of the FM receivers 22 for channel selection, as described previously. For each frequency required for the RF signal, the synthesiser 24 includes a low phase noise PLL, a high stability reference oscillator, and a low noise voltage controller oscillator (VCO). On the basis of channel frequency data loaded into the PLL, the PLL drives

the VCO to generate the required RF signal. The PLL uses the reference oscillator to provide a reference frequency. The channel frequency to be generated is loaded into each PLL via a serial data interface.

The quadrature modulator 36 includes two mixers and a phase shifter followed by a combiner. The mixers respectively mix the input I and Q streams with the carrier signal from the frequency synthesiser 24. The phase shifter imparts a phase shift on the carrier signal mixed with the Q stream based on the data on the I and Q data streams, and the combiner combines the two signals to produce the 0.3 GMSK modulated RF signal, normally generated by the transceiver of a GSM base station. The output of the quadrature modulator 36 is passed to a power amplifier 40 for the downlink path in order to increase the power of the signal for the retransmit antenna 12. Depending on the coverage area required, the output power may vary from tens of milliwatts to tens of watts. An RF duplexer 42 can be used to enable both the receive and transmit streams for a modem 4 and 6 to use one antenna 12 for the air interface.

The transmission system 2 is particularly advantageous as it can be used for repeater applications at a physical location where it is required to receive, regenerate and retransmit the GSM RF signal. The modems 4 and 6 can also advantageously be placed at different locations on opposite sides of a physical obstacle with the data link being used to effectively transport the communications signal past the obstacle. The obstacle may be a building or a geographic feature, such as a mountain.

The modems 4 and 6 can also be used for digital transmission of mobile communications signals to a remote location from a base station 50, as shown in Figure 3. A variety of different digital transmission media can be used to provide the data link 8 to transmit the 270 kbit/s data signal to a remote location, where it can then be retransmitted, if desired, using the second modem 6. The digital link may be provided by a microwave link, an optical fibre link, or a link provided by a standard twisted copper pair, normally used to transmit POTS signals. The microwave link may advantageously be used to pass the communications signals to different buildings in a central business district.

The first modem 4 may also be used to pass the communications signals to a number of second modems 6, which are located in different locations. The downlink signals on the data link 8 are simply replicated to different locations, by broadcasting or multicasting using multi-drop transmission. The uplink signals share a common data path to the first modem 4, and accordingly gating is required to allow multiple accesses for the received GSM TDMA data. The gating is executed based on a receive signal strength indicator (RSSI) determined by each receiver 22 of the second modems 6. The receivers 22 use the RSSI, and any other applicable information the receivers may derive, to determine if a valid transmission has been received from a handset, and thereby switch on and off the RS 422 driver 26 connected to the receiver, accordingly.

Many modifications will be apparent to those skilled in the art without departing from the scope of the present invention as herein described. For example, the present invention is applicable to any mobile communications system which employs digital modulation techniques, such as GSM (Group Special Mobile), DECT (Digital European Cordless Telephone), IS54 NADC (North American Digital Cellular) (or DAMPS (Digital Advanced Mobile Phone System)), JDC (Japanese Digital Cellular), CT2 (Cordless Telephone 2) and digital paging systems such as that established by POCSAG (Post Office Standard Advisory Group).

CLAIMS:

1. A transmission system for a mobile communications signal, including:

a demodulator at a first location for receiving and demodulating a first RF mobile communications signal into a digital signal; and

a modulator at a second location for modulating said digital signal into a second RF mobile communications signal and transmitting said second signal.

2. A transmission system as claimed in claim 1, including digital signal transmission media for transmitting said digital signal.

3. A transmission system as claimed in claim 2, wherein said digital signal transmission media is a microwave link.

4. A transmission system as claimed in claim 2, wherein said digital signal transmission media is an optical fibre link.

5. A transmission system as claimed in claim 2, wherein said digital signal transmission media includes a telecommunications line for transmitting digital data.

6. A transmission system, including:

a first modem at a first location including a first demodulator for receiving and demodulating RF mobile communications signals into digital signals and a first modulator for modulating digital signals into RF mobile communications signals; and

a second modem at a second location including a second demodulator for receiving and demodulating RF mobile communications signals into digital signals and a second modulator for modulating digital signals into RF mobile communications signals,

wherein the output of the first demodulator is connected to the second modulator, and the output of the second demodulator is connected to the first modulator, by digital signal transmission media.

7. A transmission system as claimed in claim 6, wherein the first modem and the second modem are respectively connected to a first RF antenna and a second RF antenna.

8. A transmission system as claimed in claim 6, wherein said first modem is connected to a base station transceiver and said second modem is connected to an RF antenna.

9. A transmission system as claimed in claim 6, including a plurality of said second modem connected to a plurality of RF antennas respectively, and wherein said first modem is connected to a base station transceiver.

10. A transmission system as claimed in claim 9, wherein the output of said first demodulator is broadcast or multicast to the second modulators of said second modems, and the outputs of said second demodulators of said second modems are selectively connected to the first modulator.

11. A transmission system as claimed in claim 10, wherein the outputs of said second demodulators are connected to said first modulators on the basis of received signal strength of the RF signals received by the second demodulators.

12. A transmission system as claimed in claim 8, wherein said first demodulator and said second modulator handle uplink communications signals of a first carrier frequency and said second demodulator and said first modulator handle downlink communication signals of a second carrier frequency.

13. A transmission system as claimed in claim 6, wherein said first and second modems each have an RF mobile communications interface and a serial data interface.

14. A transmission system as claimed in claim 6, wherein said digital signal transmission media is a microwave link.

15. A transmission system as claimed in claim 6, wherein said digital signal transmission

media is an optical fibre link.

16. A transmission system as claimed in claim 6, wherein said digital signal transmission media includes a telecommunications line for transmitting digital data.

17. A mobile communications signal modem, including:

a demodulator for receiving and demodulating RF mobile communications signals into serial digital data signals for transmission on a digital communications link; and

a modulator for modulating serial digital data signals received on a digital communications link into RF mobile communications signals.

18. A modem as claimed in claim 17, wherein said modulator includes a superheterodyne receiver which mixes the received RF signals with a local oscillator signal generated by a frequency synthesiser, the frequency of the local oscillator signal being dependent on the mode of operation of said demodulator.

19. A modem as claimed in claim 18, wherein the output of said receiver is connected to digital communication line drivers which allow a plurality of said modem to be connected to said link.

20. A modem as claimed in claim 18, wherein said mode of operation is uplink or downlink.

21. A modem as claimed in claim 17, wherein said modulator includes a baseband logic circuit and a quadrature modulator, and said baseband logic circuit generates serial in-phase and quadrature data streams for said quadrature modulator based on data received from the digital link.

22. A modem as claimed in claim 21, wherein said quadrature modulator generates said RF communications signals having a carrier frequency determined by a local oscillator signal generated by a frequency synthesiser, the frequency of local oscillator signal being dependent

on the mode of operation of said modulator.

23. A modem as claimed in claim 22, wherein said mode of operation is uplink or downlink.

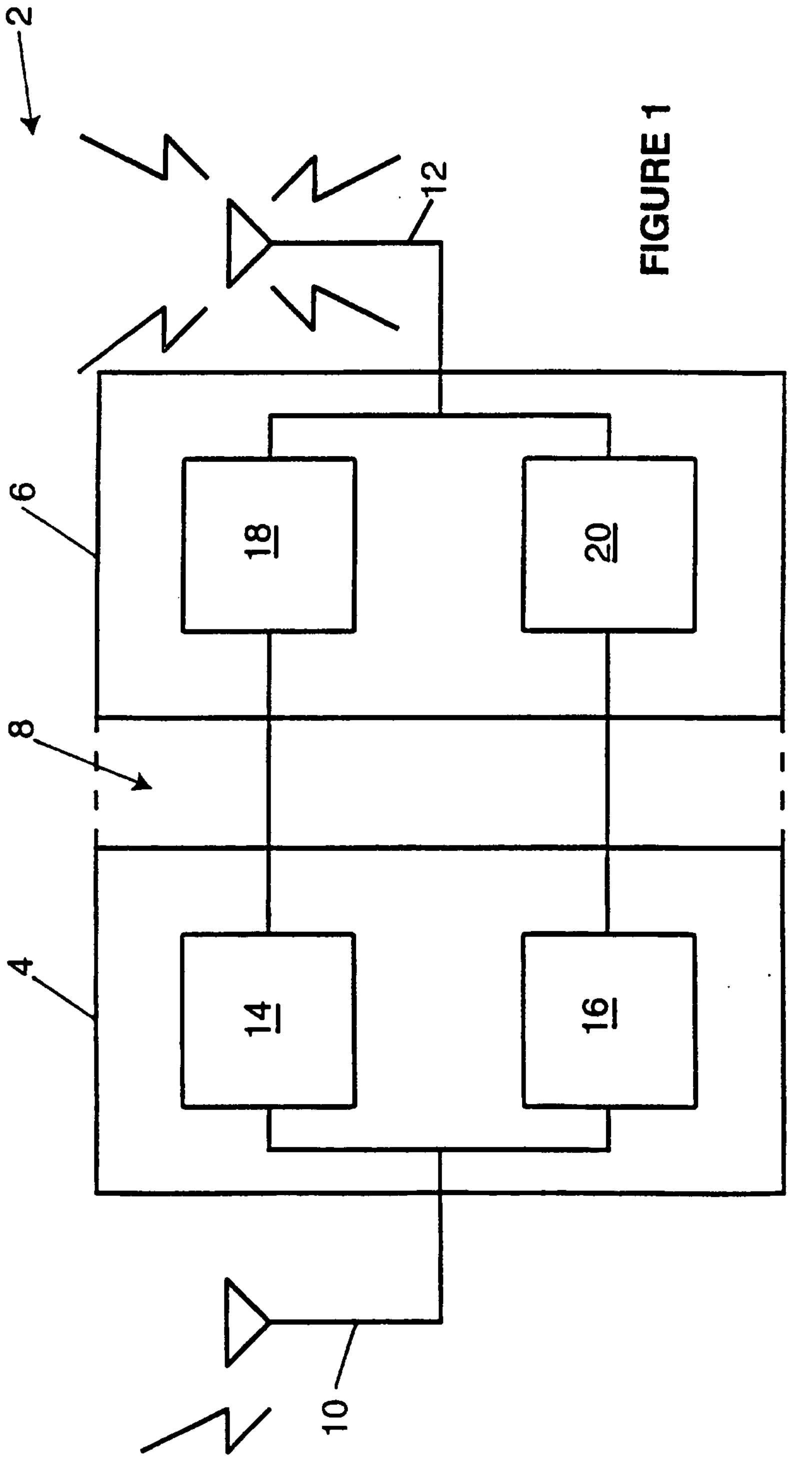


FIGURE 1

2/4

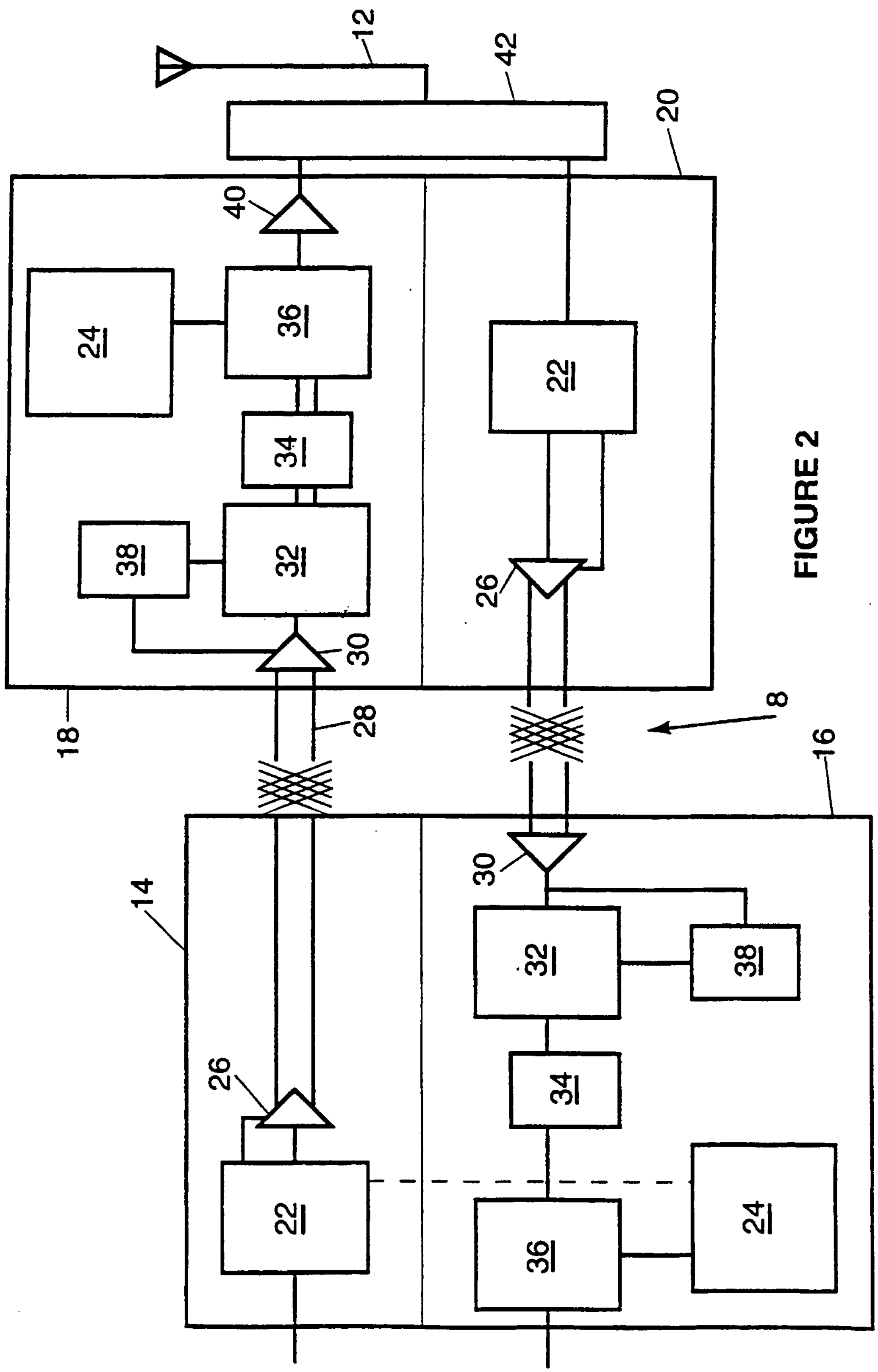
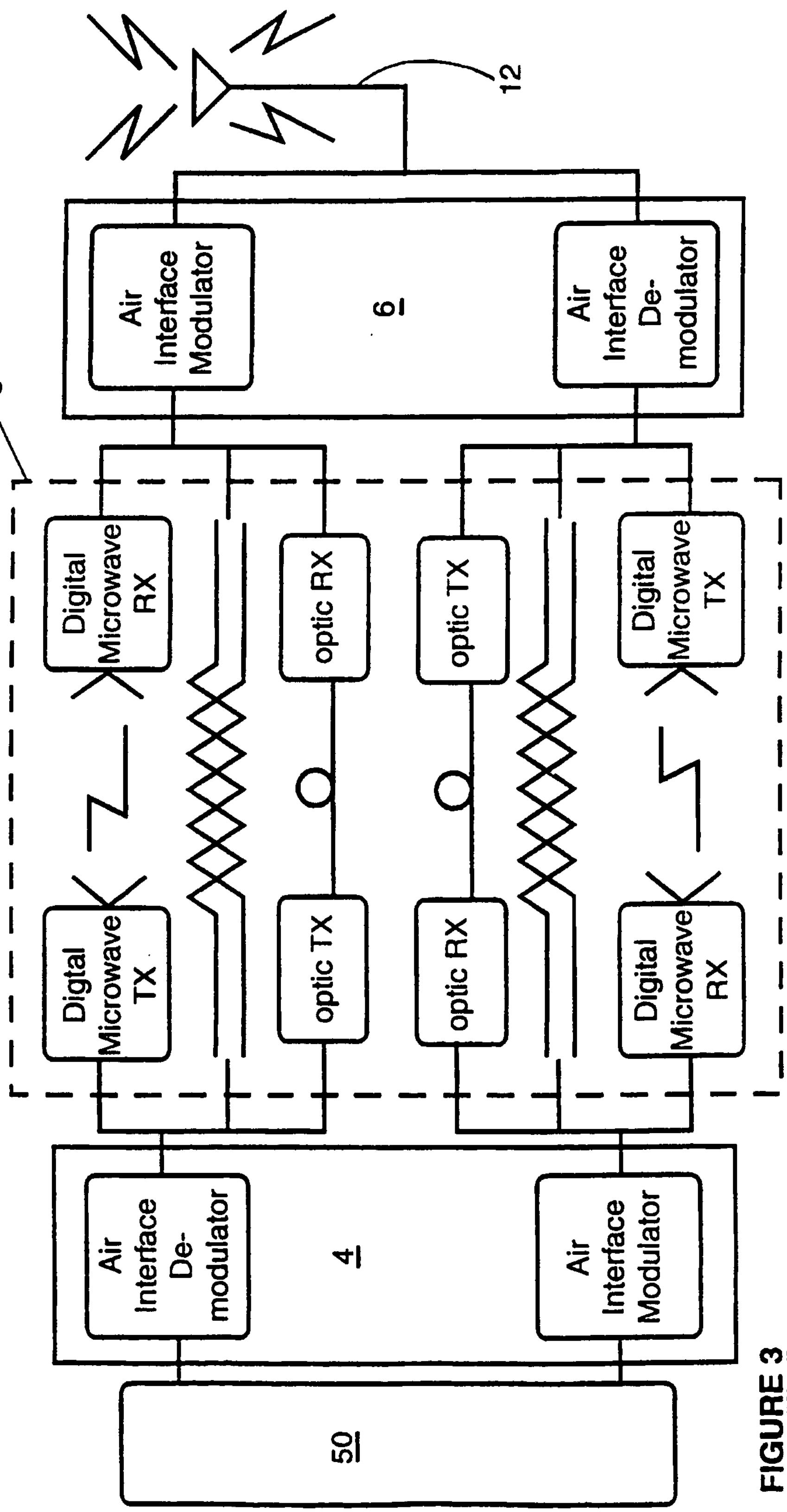


FIGURE 2


12
8
Air Interface Modulator
6
Air Interface De-modulator
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optic TX
Digital Microwave TX
Digital Microwave TX
optic TX
optic RX
Digital Microwave RX
Air Interface De-modulator
4
Air Interface Modulator
50

FIGURE 3

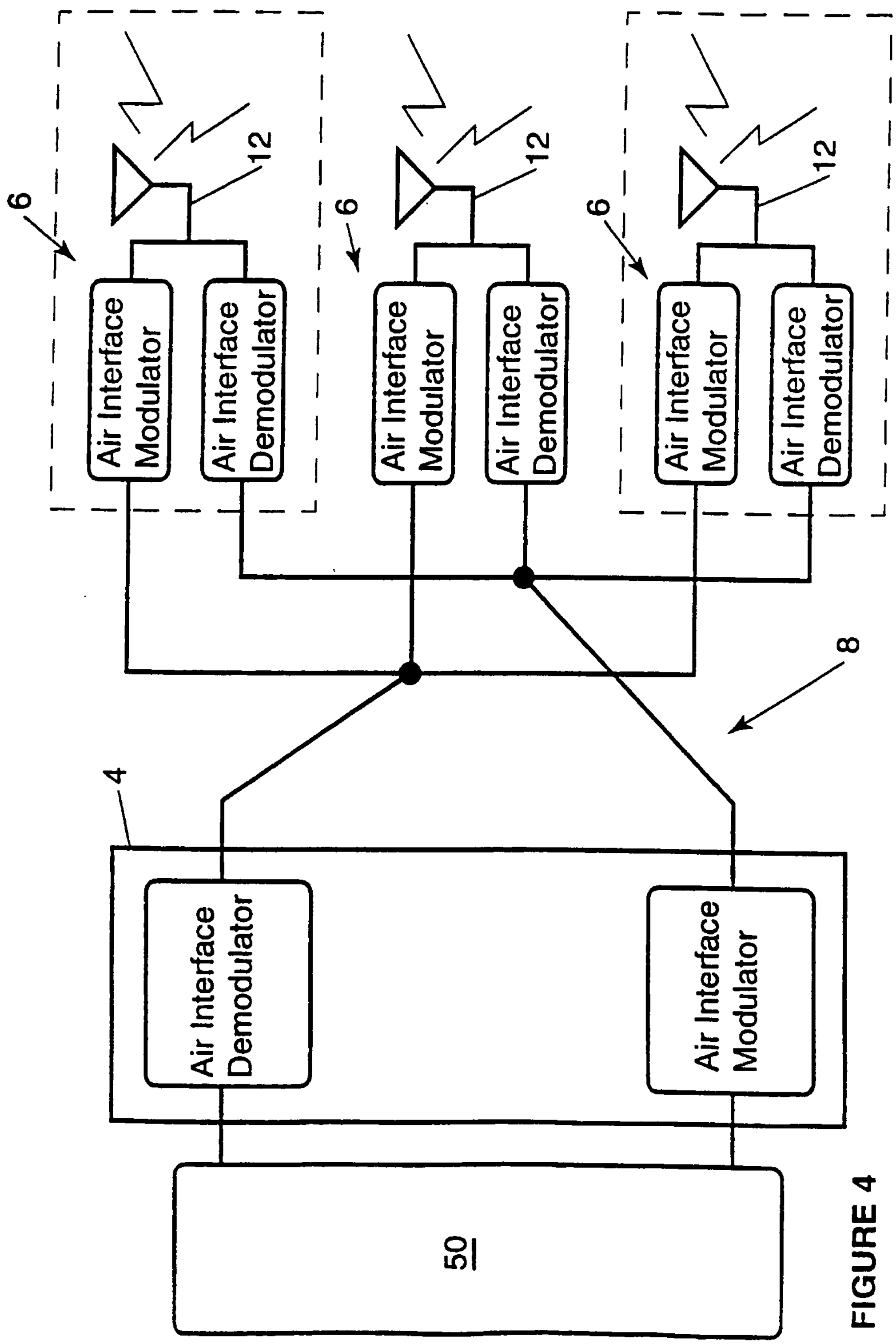
Air Interface Modulator
Air Interface Demodulator
Air Interface Modulator
Air Interface Demodulator
Air Interface Modulator
Air Interface Demodulator
6
6
6
12
12
12
8
4
Air Interface Demodulator
Air Interface Modulator
50

FIGURE 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00233

A.	CLASSIFICATION OF SUBJECT MATTER

Int Cl6: H04Q 7/24, H04B 7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B.	FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC6: as above

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT, INSPEC, USAPAT (modem, RF, repeater, transmission)

C.	DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US 5774789 (VAN DER KAAY et al.) 30 June 1998 Whole document	1
P,X	DERWENT ABSTRACTS DE 1949854, DE 19649853 & German Patents DE 19649854, DE 19649853 (HODER et al.) 4 June 1998 Abstract , Figures	1
P,X	EP 848565 (AT & T) 17 June 1998 Whole document	17

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

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Date of the actual completion of the international search	Date of mailing of the international search report
12 April 1999	20 APR 1999
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00233

C (Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98/07205 (ERICSSON) 19 February 1998 Abstract, Figures	17
X	US 5592491 (EON CORP.) 7 January 1997 Whole document	17
X	WO 94/05104 (NOKIA) 3 March 1994	17

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/AU 99/00233

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	848565	CA	2206618	CN	1190836	JP	10174175
WO	9807205	AU	40655/97	US	5878078		
US	5592491	AU	58958/94	CA	2147837	CN	1090444
		CZ	9501069	EP	666010	FI	951960
		HU	71648	IL	107399	IL	118601
		MX	9306558	PL	308533	US	5388101
		WO	9410803	ZA	9307728	US	5481546
		US	5633876	US	5678172	US	5751693
		US	5790936	US	5854793	US	5737363
		US	5633872				
WO	9405104	EP	616746	FI	923682	NO	941331
		US	5809066				

END OF ANNEX